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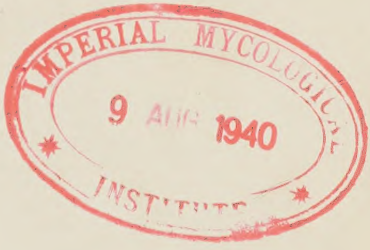
CONTROL OF BLACKFIRE OF TOBACCO IN WESTERN KENTUCKY

BULLETIN NO. 399



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Bulletin No. 399

CONTROL OF BLACKFIRE OF TOBACCO IN WESTERN KENTUCKY

By E. M. JOHNSON and W. D. VALLEAU

In Western Kentucky, during periods of frequent or heavy rains, dark tobaccos may be damaged greatly by leafspot diseases variously known as wildfire, angular leafspot, rust, and blackfire. Usually most of the injury occurs after topping and suckering. These diseases cause some loss every year, even when rainfall is below normal, as in 1936 and 1939, when losses as great as 25 percent occurred. In 1937, when rainfall in the latter part of the growing season was slightly above normal, more fields were affected and losses were as great as 50 percent on some farms. In 1938, when rainfall was abnormally high during the latter half of the growing season, many fields were destroyed and at least 50 percent of the dark tobacco crop was lost.

NAMES AND DESCRIPTIONS OF THE DISEASES

In this bulletin the terms wildfire and angular leafspot will be used only for infections on plants in the bed or on tender, rapidly growing plants in the field, where the two kinds of spots are readily distinguishable. Those caused by *Bacterium tabacum,* known as wildfire, are usually circular, dead spots surrounded by a distinct broad, yellow border, or halo. Infections with *Bact. angulatum,* known as angular leafspot, usually are angular and brownish and have no pronounced halo (figure 1). The typical spots can be produced on vigorously growing plants by spraying the leaves with a suspension of the respective bacteria in water, the only requirement being that the stomata are open and bacteria enter the leaf.[1] The term "blackfire" will be used for the late-season spotting of tobacco which occurs after topping and suckering. The disease is characterized by the presence on the leaves of dead, brown, zonate spots of various shapes, ¼ inch to several inches in diameter. The spotting is caused by a combination of wet weather, low soil fertility

1. Diachun, Stephen. Relation of stomata to wildfire infection. Phytopathology 30: 268-272. 1940.

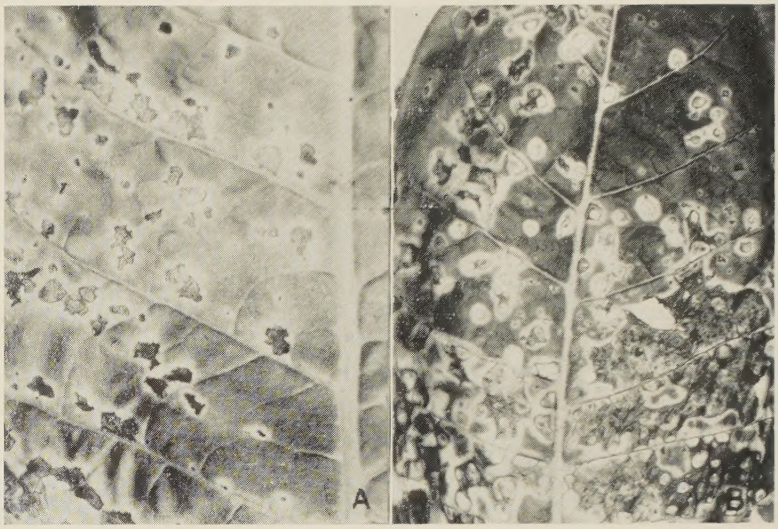

Figure 1. Recent infections of wildfire and angular leafspot on tender, young tobacco leaves. A. In angular leafspot the spots are usually brownish, angular, dead areas without conspicuous halos. B. Wildfire spots are usually circular, dead areas with conspicuous halos.

and infection with either *Bacterium tabacum* or *Bact. angulatum* (figure 2). It has not been possible to produce this type of spot by simply inoculating the leaves of topped plants with the wildfire or angular leafspot organisms. The plant must be susceptible and

Figure 2. Blackfire on dark tobacco after topping. A. Large, zonate dead spots are typical of the late-season disease. B. Blackfire spots often cover the entire surface of leaves and makes them worthless. C. Sometimes all the leaves of a plant are affected with blackfire and the plant appears scorched.

the leaves must be wet by dew or rain during several successive nights.[2]

WILDFIRE AND ANGULAR LEAFSPOT DAMAGE PLANTS IN THE BED

In springs when rainfall is high and temperature low, wildfire or angular leafspot may be destructive to small tobacco plants in the bed. Under these conditions tobacco plants the size of a dime to a dollar, if attacked, develop a wet rot and often die (figure 3). In 1937 and again in 1939 many beds were seen where half the plants were killed by either or both wildfire and angular leafspot. In both

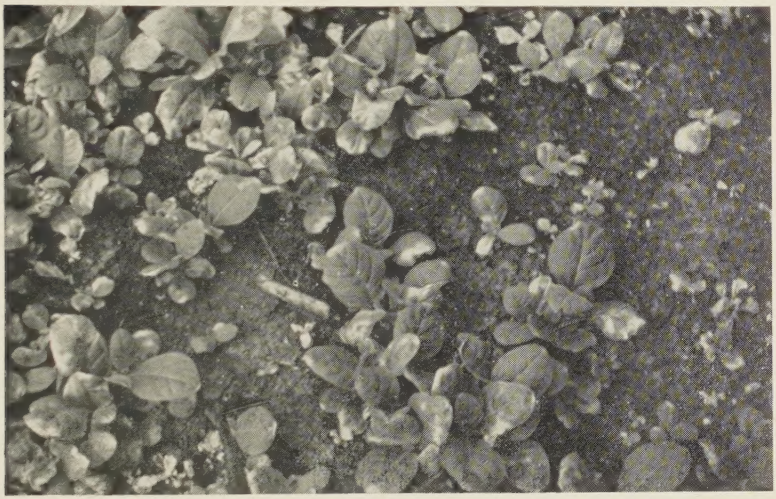

Figure 3. Wildfire damage to small tobacco plants in the bed. Small seedlings from the size of a dime to a dollar are sometimes killed. About half the plants in this bed were killed and growth of larger plants was retarded. Growers often confuse this type of injury with that of blue mold.

these years these diseases were markedly more destructive than blue mold. The diseases affect plants, from an inch to three or four inches in diameter, which are making rapid, tender growth just after they have become well established. Half-grown or larger plants are rarely killed by wildfire or angular leafspot but their growth may be retarded (figure 4).

2. Johnson, E. M., Stephen Diachun, and W. D. Valleau. Experimental production of Blackfire on Tobacco. Phytopathology. 30: 73-79. 1940.

BORDEAUX CONTROLS WILDFIRE AND ANGULAR LEAFSPOT IN THE BED[3]

Studies by the writers and others have failed to reveal the life histories of *Bact. tabacum* and *Bact. angulatum.* Angular leafspot appeared in the Station tobacco beds at Lexington almost every year and in some years an occasional spot of wildfire was present altho the usually recommended precautions to prevent them were

Figure 4. Wildfire on a tobacco plant nearly ready to set. Plants half grown or larger are rarely killed but their growth may be retarded.

followed, such as seed treatment, use of new or boiled cotton, new bed sites, new bed frames, avoidance of the use of diseased, cured tobacco and so on. For several years Bordeaux mixture has been used on tobacco beds at Lexington and Princeton and infection with wildfire or angular leafspot has been almost entirely prevented in the bed and blackfire has been controlled or reduced in the field.[4]

3 Bordeaux mixture and bluestone-lime mixture are identical.

4 Bordeaux mixture was first recommended for the control of wildfire in tobacco beds by Chapman and Anderson. Mass. Agr. Expt. Sta. Bull. 203. 1921.

Experiments were made from 1936 to 1939 in Todd and Logan counties to test, under average farm conditions, the effectiveness of Bordeaux treatment of tobacco beds in the control of wildfire and angular leafspot in the beds and of blackfire in the field. A 3-3-50 Bordeaux was applied with a sprinkling can at the rate of 1 quart to the square yard, without removal of the cotton, when the plants were forming the first true leaves and again 10 to 14 days later. The results of these tests, given in table 1, show that Bordeaux mixture almost entirely controlled wildfire and angular leafspot. Of 277 beds receiving Bordeaux, 7 had a trace of wildfire and 4 a trace of angular leafspot. Infections may have been present in these beds when the first application of Bordeaux was made because the plants were larger, in some of the beds, than they should have been for the first treatment. Of 881 untreated beds observed during the period of the test, 313, or 35 percent, were infected with wildfire and 277, or 31 percent, were infected with angular leafspot.

Table 1. Wildfire and angular leafspot in tobacco beds treated twice with Bordeaux, and in untreated beds. Western Kentucky, 1936 to 1939.

Kind of tobacco and crop year		Percent of beds with				Number of beds examined	
		Wildfire		Angular leafspot			
		Treated	Not treated	Treated	Not treated	Treated	Not treated
Dark Fire-cured	1936	5.7*	15.8	1.9*	6.6	53	76
	1937	0.0	35.2	0.0	5.6	58	142
	1938	0.0	52.7	0.0	35.5	66	93
	1939	0.0	32.4	0.0	22.5	7	71
Average		1.4	34.0	0.5	17.6	184	382
One Sucker	1936	33.3*	75.0	16.7*	6.3	6	16
	1937	0.0	35.9	0.0	18.8	17	64
	1938	0.0	30.0	0.0	18.9	15	53
	1939	0.0	34.7	0.0	14.3	2	49
Average		8.4	43.9	4.2	14.6	40	182
White Burley	1936	0.0	8.4	0.0	41.7	9	12
	1937	12.5	45.1	12.5	68.2†	16	66
	1938	0.0	51.3	0.0	90.0†	24	80
	1939	0.0	24.6	0.0	39.6	4	159
Average		3.1	32.4	3.1	59.9	53	317

*Plants received first treatment later than other beds this year.
† Some beds had both wildfire and angular leafspot.

The effectiveness of Bordeaux in preventing wildfire and angular leafspot in tobacco beds is illustrated by the following. On one

farm each of 9 tobacco beds received two treatments of Bordeaux. On one bed, a narrow strip the length of the bed, outside the frame, was not covered with cotton. When the first application of Bordeaux was made, none was applied to this strip because no plants were up and it was assumed that the area had not been seeded. Records do not show whether this uncovered strip received the second application of Bordeaux. Twenty-seven days after the first treatment with Bordeaux, when the plants were almost large enough to set, all of the plants outside the frame and cotton, which failed to receive Bordeaux, were infected with wildfire or angular leafspot, the former greatly predominating. The balance of this bed and the other 8 were free of wildfire and angular leafspot. In another instance the supply of Bordeaux was exhausted after a grower had treated all of his beds except half of one. The untreated half of this Burley bed was affected with angular leaf spot but the treated half and 5 other treated beds were free of the disease.

Bordeaux seems to be applied entirely as a soil treatment. The requisite amount of the mixture can be applied with less cost and labor with a sprinkling can than with a pressure sprayer. The use of a sprinkling can for this purpose has been found to be a more effective method than the use of a spray outfit because, by the latter method, there is a tendency to apply less than the recommended amount.

Extensive observations on the use of ready-mixed Bordeaux and copper-lime dusts, applied as dusts, indicate that they give poor control of wildfire and angular leafspot; hence they are not recommended for use.

BORDEAUX TREATMENT OF TOBACCO BEDS HELPS IN THE CONTROL OF BLACKFIRE

Tobacco fields, set with plants from Bordeaux-treated beds, were observed from the time of setting until harvest, during each of the 4 years the tests were conducted. Tobacco fields set with plants from untreated beds, located near those set from treated beds, were also observed. The results of these observations, given in table 2, show that in 1936, '37 and '39 fields set with plants from Bordeaux-treated beds were little injured by blackfire whereas the loss from blackfire in some fields set with plants from untreated beds, was

often high enough to make the crop unprofitable. Despite almost continuous rains during the latter critical half of the growing season in 1938, some profitable crops set with plants from Bordeaux-

Table 2. Losses from blackfire in tobacco fields set from Bordeaux-treated and untreated beds Western Kentucky, 1936 to 1939.

		1936		1937		1938		1939		Total fields	
Kind of tobacco	Percent of loss	Treated	Not treated	Treated	Not treated	Treated	Not treated	Treated	Not treated	Treated	Not treated
Dark fire-cured	0	19	7	27	5	1		51	10	98	22
	1	2	4	9	5	4			2	15	11
	5		5		8	3			2	3	15
	10		2		5	3	3		4	3	14
	15		2	1	3	3			1	4	6
	20				3	5			2	5	5
	25				5	6			2	6	7
	30					3				3	
	40					3	2			3	2
	50					6	14			6	14
	60					3	4			3	4
	70					3	3			3	3
	80					2	1			2	1
	90					1				1	
	100						5				5
	Average	0.1	4.0	0.7	10.0	33.0	57	0.0	7.0		
One sucker	0	7	2	10	5			26	8	43	15
	1			2	9			1	5	3	14
	5		5		2	1			2	1	9
	10				14	1			9	1	23
	15		1		5	1			4	1	10
	20		1		7				5		13
	25				8	3			1	3	9
	30				1	3				3	1
	40					3				3	
	50				3	2	4		1	2	8
	60						4				4
	70					1	1			1	1
	80					2					
	90					2	4			2	4
	100						3			2	3
	Average	0.0	7.0	0.2	14.0	45.0	73.0	0.1	8.0		
White Burley	0	6		9	2	1	1	24	6	40	9
	1			3	12	4		1	2	8	14
	5				2	2	1		1	2	4
	10				5	1				1	5
	15				1						1
	20					3				3	
	25				1		1				2
	Average	0.0	0.0	0.2	5.0	7.0	10.0	0.0	1.0		

treated beds were cut, whereas few fields set with plants from untreated beds could be cut with profit. The average loss in 1938 in fields of the dark types of tobacco set from treated beds was 39 percent and the average loss in fields from untreated beds was 65 percent. In this area many fields set with plants from untreated beds were disked under in mid-July, whereas most fields set with plants from treated beds were still not greatly injured in mid-August. In 1938 tobacco matured early and many crops could have been harvested by the third week in August if rains had not continued. These results indicate that in seasons of average rainfall or even in seasons when rainfall is slightly above normal, as in 1937, Bordeaux treatment can be expected to prevent great damage from blackfire.

USE OF PLANTS AFFECTED WITH WILDFIRE OR ANGULAR LEAFSPOT IS INADVISABLE

The importance of preventing plant-bed infection with wildfire or angular leafspot, in the control of blackfire late in the season, is further illustrated in a study made of losses in fields set from beds known to be affected with wildfire or angular leafspot (table 3). Tobacco plants in fields set from beds affected with either wildfire or angular leafspot usually show infection soon after setting. In table 4 are given the percentages of infection, 2 to 6 weeks after setting, in fields set with tobacco plants from beds affected with wildfire or angular leafspot. These results are for 1939 only, but they are similar to those of other years. Percentages of plants infected are sometimes low for some time after setting but usually there is a gradual increase in size and number of spots per plant. This increase may be very rapid if rains are frequent or if dew is heavy. Just a few days after heavy rains, fields that had a small percentage of plants affected with wildfire or angular leafspot sometimes show 100 percent infection. Sometimes an occasional wildfire or angular leafspot affected plant appears in tobacco fields from treated beds about mid-season indicating that there is an unknown source of field infection in addition to that carried to the field on diseased plants; but it is believed that these results indicate that infection in the bed is an important source and can be eliminated by Bordeaux treatment.

Table 3. Loss from blackfire in tobacco fields set from beds affected with wildfire and angular leafspot. The number of beds is the same as the number of fields.

	1936		1937		1938		1939	
Disease in the beds	Loss percent	Number of fields	Loss percent	Number of fields	Loss percent	Number of fields	Loss percent	Number of fields
Wildfire only	5	2	10	4	5	1	1	14
	15	2	15	2	15	3	5	4
	20	2	20	3	20	1	10	4
			25	1	30	1	15	2
					50	1	20	3
					60	2	25	1
					100	4	50	1
		6		10		13		29
Wildfire and angular leafspot			none	1			1	6
			5	1			5	2
			10	1			10	2
			15	1			15	2
			25	1			20	1
				5				13
Angular leafspot only			none	3			10	3
			5	3			20	1
			10	1			25	1
			15	1				
			25	1				
				9				5
Total number of fields		6		24		13		47

"BORROWING" PLANTS IS NOT ADVISABLE

Sometimes a grower may set part of his crop with plants obtained from a neighbor, usually after the neighbor has finished setting and has used most of the desirable plants. This practice is undesirable because not only wildfire and angular leafspot may be introduced

Table 4. Wildfire and angular leafspot in tobacco fields 2 to 6 weeks after setting with plants from affected beds.

Percent of diseased plants	Number of fields with	
	Wildfire	Angular leafspot
Trace to 5	13	10
6 to 10	4	2
11 to 15	5	2
16 to 25	7	2
26 to 50	6	1
51 to 100	5	2
	40	19

into the field from the bed but very often a planting from a bed which has been pulled over once has a high percentage of mosaic, if the workmen who pulled plants for the first setting, used home-cured tobacco. Also several cases are known of the introduction of black root-rot to the field from the bed. As regards the bacterial leafspots the practice is especially undesirable if a grower who has treated his beds with Bordeaux, gets plants from an untreated bed and sets them in a field with plants from treated beds.

For example, a grower treated all his beds with Bordeaux except a small isolated bed of a test variety. Two rows of plants from the latter bed were set in a field planted from a treated bed. In mid-season 30 percent of the plants from the untreated bed had black-fire. No blackfire developed in the balance of the field.

In a Burley field rows 1 to 35 and ¾ of rows 36, 37 and 38 were set with tobacco plants from a neighbor's untreated bed. Four weeks after setting wildfire was present on all the plants in these rows. The remainder of the planting was set with plants from a Bordeaux-treated bed. Four weeks after setting there was a trace of angular leafspot but no wildfire in these rows. At cutting time, there was a loss of 15 percent in the part of the field set with plants from untreated beds and none or only a trace in the part set with plants from the treated bed.

In 1937 a grower set 41 rows of one-sucker tobacco from his own beds. Forty-eight rows in the same field were set with plants obtained from a neighbor. At mid-season there was a small amount of angular leafspot in the first 41 rows and no wildfire, while in the next 48 rows the percentage of wildfire was high. At cutting time there was a loss of 10 percent in the 41 rows and 25 percent loss in the 48 rows. In the latter there were areas where many plants were not cut because of blackfire damage.

A grower who treated all his beds of dark fire-cured tobacco with Bordeaux had half the plants in the beds destroyed by cutworms; consequently he set half his crop with plants from a neighbor's untreated bed which was infected with angular leafspot. Tobacco grown from his own plants was free of blackfire at cutting time, while blackfire caused a loss of 10 percent in the half of the field set with plants from the untreated bed.

Sometimes growers who have not treated their own beds profit

by getting plants from Bordeaux-treated beds. In the epiphytotic of 1938, a grower who treated his beds, gave plants to two growers neither of whom had treated. Both these growers, whose farms were in different areas, cut good crops from the parts of their fields set with treated plants but none was cut from areas set with plants from untreated beds.

BLACKFIRE AND SOIL FERTILITY

For a number of years the writers have believed that blackfire is more likely to be destructive on soils of low fertility. In a breeding plot on the Station farm at Lexington, where fertility is high and where manure is applied annually, blackfire has not occurred. The writers have been unable to induce blackfire in tobacco in this fertile plot or in other fertile plots on the Station farm, by inoculating plants with pure cultures of *Bact. tabacum* and *Bact. angulatum,* the inoculations resulting only in wildfire and angular leafspot on rapidly growing untopped plants and usually no spots whatever on topped dark tobacco. In 1935, in a field on the Station farm, blackfire was destructive in certain areas. These were subsoil areas, low in fertility, having at one time been knolls which were leveled to improve the appearance of the field. Blackfire identical with that occurring naturally was induced in Burley tobacco in this infertile area by inoculations with pure cultures of *Bact. angulatum.* Pure-culture inoculations of tobacco on fertile areas of the same field caused only angular leafspot. Blackfire is induced without difficulty if weather conditions are favorable by inoculating dark tobacco with *Bact. angulatum* and *Bact. tabacum,* on the infertile tobacco soils of western Kentucky.

It is believed that a system of soil management which builds up large reserves of available plant food is imperative in aiding in control of blackfire for the following reasons: (1) blackfire rarely occurs on fertile soils; (2) the disease often occurs in epidemic form on soils of low fertility; (3) blackfire can be induced without difficulty in tobacco on infertile soil by inoculations with pure cultures of *Bact. tabacum* and *Bact. angulatum.*

MANURE HELPS TO PREVENT BLACKFIRE LOSSES

Several years ago the junior author observed a field of dark tobacco in Christian county that was entirely destroyed by blackfire

except for a semi-circular area where well-rotted manure had been spread. In this small area the tobacco appeared to be of an entirely different variety as the leaves were broad and smooth and showed no spotting whatever. The leaves of plants in the remainder of the field were curled downward, rough, and showed definite evidence of potash starvation. Similar observations have been made by growers. In table 5 are observations, taken over a 5-year period, on the effect of manure in the prevention of injury from blackfire. Fields on the same farm, which received manure and commercial fertilizers, are compared with those which received commercial fertilizers only. Even in wet seasons, as 1935, 1937, and 1938, damage from blackfire was much reduced and sometimes entirely prevented by the use of stable manure. In 1938 several growers reported that they produced marketable tobacco on manured areas of fields while that on unmanured areas of the same field was a total loss. It appears that to be most effective, manure should be well rotted or at least relatively free of undecomposed straw. In 1936, in a field where strawy manure was used on one-third of it, there was a loss of 25 percent from blackfire and on the balance of the field, where rotted manure was used, the loss was negligible (table 5).

Table 5. Effect of manure in preventing blackfire in dark tobacco. Observations in fields in Western Kentucky. D F stands for Dark Fired; O S for One Sucker.

Year, farm number and tobacco kind of	Percent of blackfire injury		Remarks
	Both manure applied and fertilizer	Only commercial applied fertilizer	
1935			
1 D F	trace		
1 D F		great	Had to cut green
1 D F		great	Had to cut green
2 D F	trace		Originally poorest field on the farm.
2 D F		25	Had to cut green
2 D F		25	Had to cut green
3 D F	trace		
3 D F		great	Had to cut green
4 O S	none		
4 O S		40	Some left in field
5 O S	none		Old feeding lot
5 O S		10	

Table 5. (Continued.)

Year, farm number and tobacco kind of	Percent of blackfire injury		Remarks
	Both manure applied and fertilizer	Only commercial applied fertilizer	
1936			
6 O S	trace		Well-rotted manure
6 O S	25		Strawy manure
1937			
7 O S	trace		
7 O S		high	Had to cut green. Potash hunger and frenching present
8 O S	none		
8 O S		50	Much of crop not worth cutting
9 D F	10		
9 D F		25	
10 D F	2		
10 D F		20	
10 D F		30	Had to cut some green
11 O S	none		
11 O S		10	
1938			
12 O S	25		Only tobacco on the farm worth cutting
12 O S		70	Little worth cutting
13 D F	5		Stood until mature
13 D F		60	Very little cut
14 D F	10		Hog lot. Stood until mature
14 D F		40	Had to cut green
14 D F	20		Barn lot. Stood 2 weeks longer than the fertilized tobacco
15 D F	trace		
15 D F		50	Had to cut green
16 O S	60		
1939			
17 O S	3		Stood until mature
17 O S		20	Had to cut green
18 O S	none		
18 O S		10	
19 D F	trace		Manure 3 sides of field only. Contrast between manured and not manured parts great.
19 D F		20	
20 O S	5		
20 O S		20	Cut some green
21 O S	2		
21 O S		25	Had to cut green
22 O S	trace		
22 O S		15	
23 O S	10		
23 O S		50	Had to cut 2 weeks before the above
23 O S	trace		
23 O S		15	Had to cut some green

SOILS OF THE DARK-TOBACCO AREA OFTEN ARE LOW IN FERTILITY

In the dark-tobacco districts of Kentucky the rotations used for tobacco cause a heavy draft on plant food. The common rotation is wheat, lespedeza 2 to 5 years or longer, and tobacco. Small amounts of fertilizer are sometimes used on wheat but more often none is used. The grain is threshed and the straw is rarely returned. A crop of lespedeza hay is cut in the fall following wheat harvest and hay or seed crops are harvested as long as the field is not too weedy. The lespedeza is then pastured for one to a few years. The lespedeza straw from a seed crop is rarely returned to the field from which it came. In addition to the nutrients removed in the wheat and lespedeza crops, a great deal of plant food is lost by leaching because lespedeza fields are almost bare in winter. It is not only nitrogen that is lost by leaching but also minerals such as potassium and calcium because all of the nitrogen which leaches is combined with some mineral. When the lespedeza sod is prepared for tobacco, 100 to 200 pounds of a low analysis fertilizer is usually used in the hill and manure is sometimes applied on eroded upland. The small amounts of fertilizer used for tobacco, and sometimes for wheat, are insufficient to compensate for that removed by cropping and leaching. Tobacco is also grown in continuous culture with a crimson-clover crop turned under at the full-bloom stage in the spring, between tobacco crops. This system might be expected to maintain the nitrogen supply and prevent loss of plant food by leaching but, as in the other rotation, insufficient fertilizer is used for tobacco to compensate for that removed so that the soluble mineral plant food is soon reduced to a low level. Tests of soils collected, soon after tobacco was set and rarely later than mid-season, from tobacco fields in western Kentucky, from 1937 to 1939 show that most of them are low in soluble phosphorus and potassium. Of 268 fields tested 227, or 84 percent, were too low in either phosphorus or potassium or both and only 41 fields, or 16 percent, possibly had sufficient of these elements for tobacco (table 6). This is shown graphically in figure 5. Small amounts of soluble phosphorus and potassium may be indicative of small amounts of other essential plant food elements, especially nitrogen.

The increasing use of lime and phosphate, with the consequent increase in crop yields, rapidly depletes other essential elements as potash and probably the so-called trace elements, making it more and more necessary that attention be given to supplying a well-balanced fertilizer for tobacco.

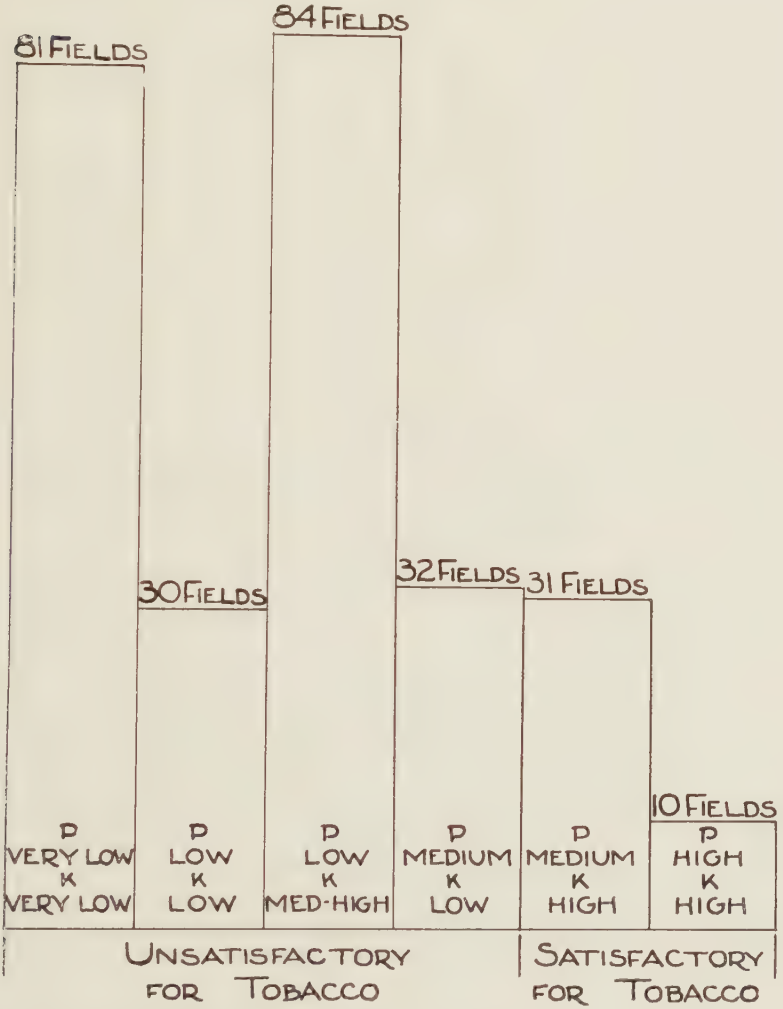

Figure 5. Soluble phosphorus (P) and potassium (K) in the soil of tobacco fields in Western Kentucky, 1937, 1938, and 1939.

Table 6. Soluble phosphorus and potassium in tobacco fields. Western Kentucky, 1937-8-9. P = phosphorus, Hi-Lo method, K = potassium, Purdue method.

Year	P very low K very low Number of fields.	P low K low Number of fields.	P low K medium to high Number of fields.	P medium K low Number of fields.	P medium K high Number of fields.	P high K high Number of fields.
1937	9	7	15	6	5	0
1938	40	16	34	16	8	3
1939	32	7	35	10	18	7
Totals	81	30	84	32	31	10

GOOD SOIL MANAGEMENT IS NECESSARY FOR PROFITABLE PRODUCTION OF DARK TOBACCO

Recommendations for soil management and fertilization for tobacco are given in Kentucky Experiment Station Bulletin No. 379, a summary of which follows.

Select the land best adapted to tobacco even if it necessitates some rearrangement of fields or more or less "patch" farming. It might be practical for many growers to select certain lots on which tobacco will be the main if not the only revenue crop. Other crops on these lots should be considered as steps in preparing land for tobacco. Tobacco land should have good underdrainage which is indicated by well-granulated reddish, brownish-red or bright yellow subsoil. Poor drainage is indicated by a light-colored, compact subsoil and the presence of dark-colored concretions (buckshot).

A tobacco soil should be fertile enough to yield 1,000 pounds of tobacco an acre in a good season without fertilization other than that used in improving the soil. A field with a good grass and legume sod, not heavily pastured, is desirable. The longer in sod, the better. Poor quality tobacco and low yields usually follow lespedeza, alfalfa, and other legumes if they are cut year after year for hay. Lands intended for tobacco should receive 300 to 400 pounds of 20-percent superphosphate broadcast ahead of seeding the grass and legume mixture. If the soil has not been limed, only sufficient lime should be added for the legume. On many soils a ton is sufficient. The land should then be seeded to a good pasture mixture such as 3 pounds of redtop, 8-10 pounds of orchard grass, 3-4 pounds of Kentucky bluegrass, 3-4 pounds of Canada bluegrass,

5 pounds of native red clover, not over 5 pounds of Korean lespedeza, and 2 pounds of white clover per acre. It is desirable that the grass-legume mixture be pastured rather than cut for hay and pastured lightly or not at all the year preceding tobacco.

The use of 6-8 tons of manure with a high-grade fertilizer will increase the yield and quality of dark tobacco. A 4-10-6 fertilizer or a similar analysis is satisfactory for dark tobacco. The amount to use varies with the fertility of the soil and the amount of manure used. On more fertile and heavily manured soils not less than 300 pounds, and on the less fertile soils 600 to 700 pounds or more should be profitable. On phosphate-deficient soils (most western Kentucky soils) that have not been liberally fertilized with phosphate in producing the sod for tobacco, 300-400 pounds of 20-percent superphosphate will probably be profitable on the tobacco and will be of great benefit to the wheat and grass that follow.

A study of the soil management practices used at the Mayfield

Figure 6. Dark fire-cured tobacco topped high. On soil of satisfactory fertility dark fire-cured tobacco may be topped at 16-20 leaves. Yields of 1000 pounds per acre of the leaf grades are not unusual.

and Greenville soil fields and at the Princeton substation will be of benefit to dark-tobacco growers of western Kentucky.

DISCUSSION

Bordeaux (Bluestone-lime) treatment should always be used because it is easy to apply and one is almost certain to have wildfire and angular leafspot free plants for setting. The tests also indicate that, in most years, Bordeaux treatment of tobacco beds prevents injury from blackfire in the field late in the season or greatly reduces it.

It is common observation that early-maturing tobacco plants topped low (10-12 leaves) are more susceptible to blackfire injury than those topped high (16-20 leaves). The contention of some dark-tobacco growers that dark tobacco topped higher than 12 leaves will not cure with sufficient body, is probably true for most dark-tobacco soils as they are now managed. Most of these soils probably would not support plants of greater size without additional nutrients. With proper soil management, heavy manuring and fertilization, the height of topping can be increased over that now commonly used, with resultant higher yields and freedom from blackfire. In certain areas in western Kentucky, growers are producing, by the liberal use of manure and commercial fertilizers on grass sods, high yields and high quality of dark fire-cured tobacco topped at 16-20 leaves. Yields of 1,000 pounds of the leaf grades are not unusual (figure 6). Where dark tobacco is topped at 10-12 leaves, in most of the dark tobacco district, a total yield of 1,000 pounds per acre of all grades is considered satisfactory (figure 7). In the wet year of 1938, one of the growers who fertilized heavily and topped high, harvested a crop free of blackfire while neighbors who topped at 10 leaves on soils low in fertility cut little or no tobacco because of blackfire.

Heavy fertilization, manuring and proper soil management not only produce tobacco which can be topped higher and give heavier yields of the desirable grades but definitely increase the resistance of the tobacco plant to the leafspot diseases after topping. The soil should contain liberal quantities of available phosphorus and nitrogen compounds but in addition should contain liberal quantities of potash. An actual or partial deficiency of potash has, for a long

time, been recognized as one of the causes of susceptibility to destructive leaf diseases. The survey of tobacco soils reported in this bulletin proves that very few fields in which tobacco is grown contain sufficient available nutrients to produce a satisfactory crop of tobacco. In addition to Bordeaux mixture the tobacco grower

Figure 7. Dark fire-cured tobacco topped low. On most dark-tobacco soils dark fire-cured tobacco is topped at 10-12 leaves. A yield of 1000 pounds per acre of all grades is considered satisfactory.

must rely on good soil management if he expects to produce dark tobacco free from leafspot injury.

SUMMARY

Blackfire, a late-season disease of tobacco, caused by either *Bacterium tabacum* or *Bact. angulatum* together with wet weather and unsatisfactory soil conditions, yearly causes some loss of dark tobaccos and in seasons of heavy rainfall, as in 1938, destroys many crops.

Blackfire is characterized by the presence on the leaves of to-

bacco, usually after topping and suckering, of few to many dead, brown, zonate spots of various shapes, 1/4 to several inches in diameter.

Infections with *Bact. tabacum* and *Bact. angulatum* on young, actively growing plants are easily distinguishable. The former, known as wildfire, are usually circular, dead areas surrounded by a broad lemon-yellow halo. *Bact. angulatum* spots, known as angular leafspots, are usually angular, dead, brown areas with no haloes. Wildfire or angular leafspot often destroy many young plants in the bed. Half-grown or larger seedlings are rarely killed but their growth may be retarded.

In extensive tests in western Kentucky from 1936 to 1939, a 3-3-50 Bordeaux mixture applied to tobacco beds with a sprinkling can without removal of the cotton, when the first true leaves appeared and again 10-14 days later, usually completely prevented wildfire and angular leafspot in the bed. Blackfire was either entirely prevented or greatly delayed in the fields set from treated beds. In the few treated beds where these diseases appeared fewer than twelve affected plants per bed were found.

Damage from blackfire to dark tobacco types, in fields set from treated beds, was slight in 1936, 7 and 9. During these years the damage in fields set from untreated beds was sometimes as great as 50 percent. In 1938, when rainfall was excessive thruout the growing season, the average loss in fields set from treated beds was 39 percent and in fields set from untreated beds 65 percent.

Wildfire or angular leafspot develop in the field soon after setting if the diseases were present in the bed. There is a gradual increase in size and number of spots and if rains are frequent or heavy, damage from blackfire develops rapidly in such fields. In the rainy year of 1938 many fields that had wildfire or angular leafspot soon after setting were destroyed with blackfire by mid-July, whereas those from treated beds were still little injured by mid-August.

Blackfire causes greater damage to tobacco on soils of low fertility. The disease is rarely of consequence on the highly fertile soils at Lexington nor at the Princeton substation and Greenville and Mayfield soil fields where the soils are being improved by a good system of soil management. In western Kentucky, where

blackfire damage is high, tests show that more than 80 percent of the fields are too low in phosphorus and potassium for satisfactory growth of tobacco. This condition, especially low potassium, increases the susceptibility of plants to injury.

By using a rotation with 2 to several years of a grass-legume mixture, not too heavily pastured, and generous applications of manure and fertilizers, dark tobacco can be topped at 16-20 instead of 10-12 leaves, and may be expected to give increased yields of high-quality tobacco relatively free of blackfire damage.

Casual observations for a number of years and more detailed observation from 1935 to 1939 indicate that applications of well rotted stable manure often prevent damage from blackfire.

A combination of Bordeaux treatment of plant beds and the best soil practices must be followed if high yields of relatively disease free, high-quality tobacco are to be obtained.